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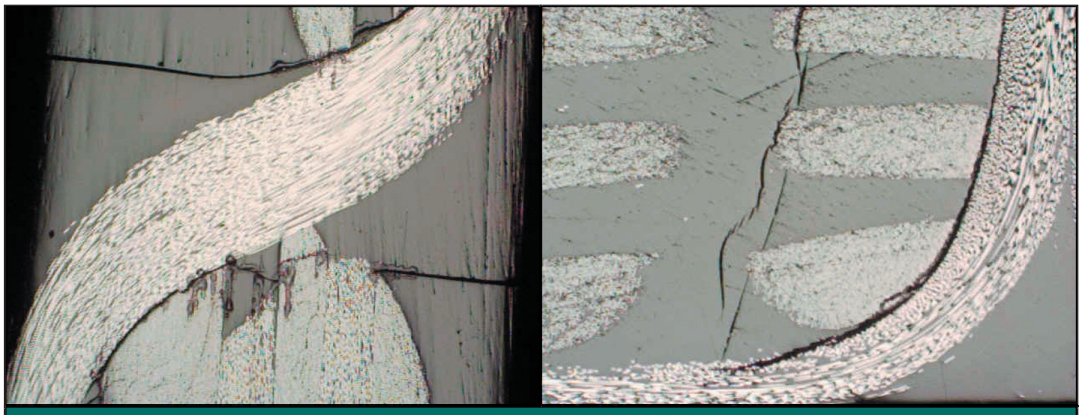
Science and Technology for Tomorrow's Air and Space Force

Success Story

DIRECTORATE DEVELOPS SOFTWARE-BASED MODELING TOOL THAT WILL AID MATERIALS QUALIFICATION OF TEXTILE AND PREFORM COMPOSITES



Micrographs showing cracks in 3-D preform composites. In these micrographs, smooth regions are the resin (matrix) regions with surrounding 3-D curved reinforcing yarns. Interface cracks and resin (matrix) cracks are visible.

A software-based analytical tool for textile and preform composites will save manufacturers time and costs related to materials qualification by supplying reliable information about the strength, stress, and complex three-dimensional (3-D) failure modes. This information will allow manufacturers to quickly produce and incorporate the emerging lightweight, low-cost, load-bearing structural materials needed to sustain present and future Air Force aviation, space, and munitions applications.

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Accomplishment

Engineers from the Materials and Manufacturing Directorate developed a software-based analytical tool that will supply engineers and composite manufacturers with important materials qualification information about the stress, failure initiation, failure modes, and strength of textile and preform composite materials. Materials manufacturers already experienced success using the model to determine the structural characteristics of 3-D woven textile composites.

Background

Working with composite materials, directorate engineers discovered that traditional composite laminates, containing no fiber reinforcement in the thickness direction, are as delamination resistant as a textile composite with woven or braided fibers. Weaving fibers in three dimensions increases the damage tolerance, impact resistance, through-the-thickness strength, and stiffness of the composite.

Preform (textile) composites enable low-cost manufacturing processes (such as vacuum-assisted resin transfer molding) for fabricating structural components of complex shapes. Thus, textile composites are becoming a widely used and affordable medium in advanced composite manufacturing.

Manufacturers use textile composites as the key material forms to produce the complex shapes and structures that exist in cutting-edge Air Force aviation, space, and munitions applications. However, engineers face challenges analyzing the structural performance of 3-D curved fiber reinforcements (yarns).

Engineers from the directorate's Structural Materials Branch developed a numerical modeling tool, which runs on a software application that combines the stress analysis of curved fiber yarns in conjunction with finite element analysis. Manufacturers provide the fiber-reinforcing direction (fiber yarn direction), its dimensions, and properties of the fiber and matrices.

Next, the model calculates the stresses experienced by a fiber yarn and the matrix material when a load is applied. With the strengths of the fiber and matrix defined, researchers can conduct trend prediction to determine how cracks or failure will initiate.

Materials and Manufacturing
Emerging Technologies

Additional information

To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (02-ML-14)